REMARKS

Claims 1 and 5 are of record, with claim 5 being withdrawn.

Claim 1 is rejected under 35 U.S.C. §112 for lack of a proper antecedent for an "ab" surface. The claim is proposed to be amended to correct this.

The Examiner indicated in the Final Office Action that "it is not clear what is intended by the ab surface". Attached is a copy of the publication "*Introduction to High-Temperature Superconductivity*", Thomas P. Sheahen, Western Technology Incorporated, Derwood, Maryland. From this publication it is seen (page 142) that terms such as "a direction" and "a and b direction" are commonly used in the art, to which the subject invention pertains. A person having ordinary skill in the art knows that directions which are represented simply by "a", "b" and "c" for any type of superconductor such as Y-Ba-Cu-O or RE-Ba-Cu-O indicate a coordinate system which is shown in a left top drawing of page 142 of the attached publication. Use of such terminology for directions which are represented simply by "a", "b" and "c" is common knowledge in the art, and this is the reason why the "ab surface" need not particularly be defined and is supported as set forth in claim 1.

An amendment is also proposed to claim 1 to correct an error in that the polished contact surfaces of the connector material are parallel to and not perpendicular to the a-b direction of the body. This proposed amendment only corrects an error in the claim that should be clear from reading the Specification. It does not add new matter or raise a new issue.

The foregoing amendment should be entered since it clearly places the application in condition for allowance.

If the amendment is not entered for purposes of placing the application in condition for allowance, then its entry is requested for purposes of appeal.

Prompt and favorable action is requested.

Dated: November 1, 2004

Respectfully submitted,

By _____

S. Peter Ludwig
Registration No.: 25,351
DARBY & DARBY P.C.
P.O. Box 5257
New York, New York 10150-5257
(212) 527-7700
(212) 753-6237 (Fax)
Attorneys/Agents For Applicant

Introduction to High-Temperature Superconductivity

Thomas P. Sheahen
Western Technology Incorporated
Derwood, Maryland

Plenum Press • New York and London

lattice constant, so that the unit cell would not be truly repetitive if we stopped counting after one cycle of the atoms.

Close scrutiny of Figure 8.3 reveals a total of nine copper atoms: four at the top, each shared by eight adjoining unit cells; four similar ones at the bottom; and one exactly in the middle of the drawing, not shared by any other unit cell. Summing the fragments, 4/8 + 4/8 + 1 = 2, giving two coppers in one unit cell. Similarly, there are eight atoms of lanthanum (or its substitute strontium) along the edges of the unit cell, each shared by four unit cells; plus two others (one near the top and one near the bottom) contained entirely within this unit cell. The net lanthanum content is four in each unit cell. The many oxygen atoms can be summed in the same way; Figure 8.3 contains 46 oxygen atoms, 24 of which lie entirely outside the unit cell; summing the fragments gives a total of eight oxygens participating in this unit cell.

This may seem tedious, but is indispensable for understanding the more complicated thallium and bismuth compounds.

The 2-1-4 compounds have only one CuO_2 plane. Looking at the exact center of Figure 8.3, the CuO_2 plane appears as one copper atom surrounded by four oxygen atoms, with one LaO plane above the CuO_2 plane and one below it. These LaO planes are said to be *intercalated*. Obviously, the entire structure is layered.

The CuO_2 plane is termed the *conduction plane*, and superconductivity takes place within it. The intercalated planes are called *charge-reservoir layers*. When the intercalated plane contains mixed-valence atoms, electrons are drawn away from the copper oxide planes, leaving holes to form the pairs needed for superconductivity. This mechanism is known as a *charge-transfer model*. The possible choices for placing specific atoms at the various sites opens the door into the topic of doping, i.e., changing the electron concentration. This is a very broad subject, which greatly affects superconductivity in these materials. We defer further discussion of this topic until Chapter 10 so as to concentrate in this chapter on structure alone.

8.2.3. $YBa_2Cu_3O_{7-x}$

The first superconductor found[11] with $T_c > 77$ K, and subsequently the most widely studied HTSC, is yttrium barium copper oxide ($Y_1Ba_2Cu_3O_{7-x}$), commonly termed "1-2-3." Its structure appears in Figure 8.4. It is related to the perovskite structure as follows: by tripling the perovskite (ABO_3) unit cell and substituting one yttrium atom for every third barium atom, the formula $Y_1Ba_2Cu_3O_9$ results. However, a little more than two oxygen vacancies are required for superconductivity. The formula can be thought of as $Y_1Ba_{2.1}Cu_3O_{9-2-x}$. The unit cell is orthorhombic—almost but not quite three cubes stacked upon one another.

A key feature of this unit cell is the presence of two layers or planes of CuO_2. Other HTSCs (the bismuth and thallium compounds) also form crystals which are relatives of the basic perovskite structure, again featuring layers of CuO_2. There is widespread agreement that the superconductivity takes place in the CuO_2 planes. One particularly noticeable feature in Figure 8.4 is that the two copper oxide planes are separated by a single yttrium atom; the yttrium plane contains no oxygens. Basically, this is because Y has a valence of +3, as contrasted with the +2 of Ba. Because of the *bond sum rule* for charge balancing, each Y coordinates with eight oxygens (valence = −2), located in the layers above and below the Y atom. With no oxygens in the yttrium layer, the formula is $Y_1Ba_2Cu_3O_7$ instead of $Y_1Ba_2Cu_3O_9$.

The role of yttrium is very minor: it just pries the two CuO_2 layers apart. When yttrium is replaced by many of the lanthanide series of rare-earth elements, there is no appreciable

BEST AVAILABLE COPY

BEST AVAILABLE COPY

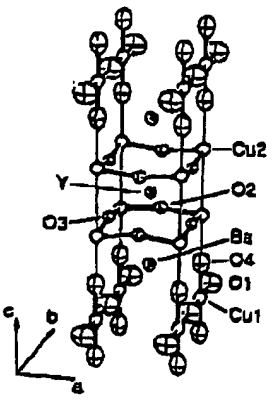

Figure 8.4. Structure of the double layered $YBa_2Cu_3O_7$ compound. This drawing has Y at the exact center and Cu atoms on the four edges. Oxygen atoms play four different roles in this unit cell, depending on position; also, there are two different roles for copper atoms. The designations O1, . . ., O4 and Cu1, Cu2 identify each type of atom.

change in superconducting properties. Thus, the yttrium (or other choice) serves only as a spacer—a "shim" between CuO_2 layers.

Outside this sandwich (but still within the unit cell) is a BaO plane. Referring to Figure 8.4, this means one barium atom surrounded by four oxygens along the edges of the unit cell. Finally, at the top (or bottom) of each unit cell is a copper oxide region that has certain oxygens missing. Since this does not qualify any longer as a CuO_2 plane, it is known as a copper oxide *chain*. Figure 8.4 shows the single Y atom and the two Ba atoms; the copper oxide planes near the middle each contribute one net copper atom (their four coppers are shared with four unit cells), and the top and bottom chains each contribute 1/2 coppers (four copper atoms shared with eight unit cells). Hence the name "1-2-3."

The additional nomenclature O1, O2, O3, O4 has been introduced in Figure 8.4 to help distinguish the four different roles played by oxygen atoms. O1's occur in the copper oxide chains; O2's lie in the CuO_2 planes; O3's likewise occur in the CuO_2 planes, but they are in line with the O1's in the chains above and below; O4's are associated with barium atoms. Likewise, we distinguish between Cu1's in the chains and Cu2's in the planes.

The missing oxygens are very important in $Y_1Ba_2Cu_3O_{7-x}$. The subscript x in the formula indicates that a fraction of the conventionally expected oxygens are missing. T_c maximizes near 92 K when $x = 0.15$; should $x = 0.50$, superconductivity goes away. Figure 8.4 depicts $Y_1Ba_2Cu_3O_7$ ($x = 0$). Note the missing oxygens along the *a* direction at the top and bottom of the unit cell. (If these oxygens were not missing, the formula would be $Y_1Ba_2Cu_3O_8$.) The missing oxygens result in the lattice parameters $a \neq b$, and the unit cell is orthorhombic. As x increases from zero, oxygen vacancies appear in the chains. At $x = 0.50$, there is equal probability for vacancies to occur along the *a* and *b* directions, causing the unit cell to have square symmetry. When that happens, the lattice parameter $a = b$, and the crystal is tetragonal. In 1987, when it was learned that the tetragonal phase is *not* superconducting, theorists came up with a "chain" theory of HTSC, which later was abandoned.

Typical $Y_1Ba_2Cu_3O_{7-x}$ dimensions are compared with those[4] of NbTi in Table 8.1.

8.2.4. Alternative Drawings

There is another, entirely different way to draw these crystals, using polyhedrons of copper oxide. Six oxygens surrounding a copper atom form an 8-sided octagon, and these attach to various barium and yttrium atoms. Figure 8.5 presents the YBCO unit cell in that form. Historically, the different types of drawings have been a matter of choice, with most